BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D. C. 20036

SUBJECT: New Ideas and New Work at the Fifth Symposium on Remote Sensing of Environment - Case 710

DATE: May 14, 1968

FROM: B. E. Sabels
W. L. Smith

ABSTRACT

This paper sums up new ideas and progress reported at the Fifth Symposium on the Remote Sensing of Environment, Ann Arbor, Michigan, April 16-18, 1968. Several new, potential space techniques concern themselves with atmospheric composition and clear air turbulence, thunderstorm water content, and pollution mapping. Other techniques, potentially limited to aircraft altitude or surface activities, deal with compositional mapping, side-looking sonar of the sea, magnetometry of ocean wave profiles, and surface conductivity mapping. Progress in IR, radar and other fields covers most of the established fields of remote sensing in agriculture, geology, and related disciplines.

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MEMORANDUM FOR FILE

INTRODUCTION

The Fifth Symposium on Remote Sensing of Environment took place at the University of Michigan in Ann Arbor during April 16-18, 1968. The meeting in general has been discussed in a recent memorandum by W. W. Elam.* Topics and techniques of interest in remote sensing of the lunar surface have been reviewed by W. L. Piotrowski.** The current program and considerations for the future for Earth Resources Survey, as largely discussed during the meeting, were recently appraised by F. G. Allen and B. E. Sabels.*** The present paper attempts to point out progress in ideas and results that were reported at the meeting for the first time.

The material is divided into the categories: potential space techniques; airborne and surface techniques; new applications of infrared, radar and microwave technology; and other studies.

I. NEW POTENTIAL SPACE TECHNIQUES

A. Optical (Laser) Radar Studies of the Atmosphere by J. D. Lawrence et al., NASA Langley.

The paper described the experimental and theoretical aspects of a series of airborne and ground based optical radar scattering measurements of the atmosphere up to 26 KM altitude. The ground based and airborne measurements show a sharp decrease in aerosol scattering in the first few KM, followed by predominantly molecular scattering to 12KM, and then deviating from molecular scattering reaching a relative maximum near

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*Trip Report - Fifth Symposium on Remote Sensing of Environment at Ann Arbor, Michigan, Memorandum for File, by W. W. Elam, April 30, 1968.

**Trip Report - Fifth Symposium on Remote Sensing of Environment, April 16-18, 1960, Ann Arbor, Michigan, Memorandum for File, by W. L. Piotrowski, May 2, 1968.

***Current Program and Considerations of the Future for Earth Resources Survey by Remote Sensing, Memorandum for File, by F. G. Allen and B. E. Sabels, May 2, 1968.

17KM. This relative maximum is about 1.8 times the expected molecular scattering at this altitude. The optical radar has potential applications in meteorology and in operational fields (navigation, communication, jet stream activity).

B. Clear Air Turbulence Detection (CAT) by IR Spectrometry, G. K. Mather, NRC, Ottawa, and M. Weiss, Barnes Engineering Co.

The paper surveyed microwave, laser, electric field and IR techniques of CAT detectors and focussed on IR. A prototype Barnes IR spectrometer operating in the 15 micron CO_2 region was flight tested in the Canadian National Aeronautical Establishment (sic!) T-33 turbulence research aircraft. The objective was to seek out areas of clear air turbulence and to establish the extent of advance warning in order of miles by using the IR spectrometer, then to confirm the presence of CAT and the associated increase in air temperature at the site of the turbulence.

Advance warning of up to 8.5 nm before interception were recorded.

C. Pollution Survey From Space by A. R. Barringer, et al., Toronto

The paper described a correlation spectrometer for the sensing of SO_2 and NO_2 from aircraft and spacecraft. A similar instrument has been recently proposed by Barringer, in conjunction with IBM, for application in the Nimbus programs. The instrument used UV and visible absorption spectra of suitable molecules and provides detection by a correlation system. Several industrial and metropolitan areas were monitored from aircraft, under HEW sponsorship. Sensitivities in order of hundreds of integrated ppm, over the light path, have been documented, as compared to noise figures in the tens of ppm.

D. Radiometry of Thunderstorm Cells - M. T. Decker and E. J. Dutton, ESSA Boulder, Colorado

The thermal noise emission from thunderstorm cells has been measured at 10.7 Ghz (2.8cm) with an 18m diameter parabolic antenna. The integrated liquid water content of the cell can be monitored, in addition to the total attenuation of EM energy passing through the cell and the noise degradation of sensitive communication systems. The technique used clear sky radiation for calibration. Integrated liquid water content is computed from the total absorption and the absorption cross section for water drops as adjusted for the estimated liquid water temperature. A storm at a distance of 50 KM was monitored, and the water content mapped.

The principal limitation lies in the uncertain estimate of the scattering cross section. Addition of radar reflectivity and radiosonde data will help overcome this problem.

II. AIRBORNE AND SURFACE TECHNIQUES

A. Microwave Applications for Engineering Investigations of Terrain - A. T. Edgerton, Space General Corp., El Monte, California

Polarized and unpolarized microwave traces and images have been used recently to map soil moisture and ground water, sea state and surface rock composition in the 1 to 100 Ghz range. The work has shown that a suitable imaging system can provide a computer printout of compositional characteristics reflected in surface brightness temperatures, which are similar to multiband printouts of crop maps produced by IR techniques. Microwave sensing is not affected by diurnal temperature variations to the extent of IR sensing; however, its resolution is inferior to IR, at least in the present state of the antenna art.

B. Airborne Magnetometry for Ocean Wave Profiling - R. Baker and P. W. U. Graefe, NRC, Ottawa

The movement associated with ocean waves of conductive sea water interacts with the earth's magnetic field to produce circulating electric eddy currents in the sea. These currents produce magnetic fields which can be detected by floating, submerged or airborne magnetometers. Sample magnetic measurements made at various aircraft altitudes between 200 and 1000 feet observing waves between 8 and 10 feet height, 9 to 12 second periods, showed observed magnetic variations from 0.05 nt (nanotesla) to 0.3 nt, when the calculated variations are 0.03 to 0.3 nt.

C. Radiophase Conductivity Mapping - A. R. Barringer and J. D. McNeill, Toronto

The signals transmitted by several very high powered VLF communications stations built by the U. S. Navy propagate as ground waves for thousands of miles and penetrate to distances of many hundreds of feet below the earth's surface. They induce eddy currents in dipping sheets* of conductivity such as geological fault zones, graphite beds, contacts** and sulphide ore bodies, and they are associated with small currents which flow in directions which are radial to the transmitter in homogeneous or horizontally stratified ground. Signals from the U. S. station in Maine have been observed in Sweden.

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*dipping- the plane of the sheet forms an angle with the horizontal plane.

**contacts- divisions between rock types.

The Radiophase system utilizes the VLF signals to detect the presence of dipping conductive sheets in underlying terrain and to estimate the impedance of a homogeneous or horizontally stratified earth. The airborne version employs two orthogonal magnetic dipole antennas mounted horizontally, a horizontal trailing electric antenna and a vertical electric antanna. The relationships between fields and antennas give the azimuth direction of the secondary field generated by currents in the ground which makes it possible to identify the strike direction of the geological features causing the secondary fields. The penetration is 50 to 5000 feet depending on conductivity and frequency. Flight altitude is 200 to 1500 feet depending on the degree of detail desired. Other potential applications are conductivity mapping in fresh water bodies leading to ion (pollution) sources. In conjunction with remote temperature mapping, salinity mapping at sea and in estuaries should be feasible.

NEW APPLICATIONS OF INFRARED TECHNOLOGY

Project Fire Scan - Summary of five years progress in airborne infrared fire detection, S. N. Hirsch, Northern Forest Fire Laboratory, Montana.

The data indicates that the IR system can detect forest fires with a high degree of reliability. During 1967 21 missions were conducted, detecting 600 fire targets, within 1/8 mile accuracy.

Infrared mapping of large fires became operational in July 1966, and imagery has been supplied on 68 forest fires through 1967. The airborne unit has generally been able to plot accurate perimeters and make the information available to fire managers within one hours time.

Remote Sensing Volcanic Activity on Surtsey, Iceland (August-October 1966, J. O. Friedman, USGS, and R. S. Williams, AFCRL.

An HRIR system on Nimbus II (3.45-4.07μ) and an airborne M1A1 thermal IR scanning radiometer (4.5-5.5μ) concurrently recorded the IR emission from the fissure of the volcano. The measurements permitted calculation of the relationship of radiant emission to the total heat flow of the eruption.

Aircraft Polarimeter and Photometric Observations, W. G. Egan, Grumman Aircraft Engineering Corp.

Aircraft Sensing of the Earth's surface and of the atmosphere, employing an electronic large scale (non-imaging) polarimeter/photometer, has been undertaken. Measurements were made in the 0.3 to 3μ spectral region. At an altitude of 1000' above the terrain, measurements indicated that polarization may be useful

to identify forest stands below the resolution limits of the instruments due to the morphology of the trees. Sensing of sea areas indicates that polarization may offer the possibility of determining the surface wind direction. Polarization techniques may be valuable for increasing contrast in the imagery from photography, vidicons, and imaging scannners.

Detailed Plant and Soil Thermal Regime in Agronomy - C. L. Wiegand, et al., USDA, Weslaco, Texas

The effect of several agricultural variables on thermal behavior as sensed by an airborne thermal scanner is described. Interpretation by means of microdensitometer techniques indicated the time of day, tillage, moisture stress, crop cover conditions, and other treatments on the thermal regime of the plants and soils, influence the imagery. The authors stress the need for internal calibration of the scanner and for knowledge of the insolation conditions pertinent to the specific imagery.

Previsual Detection of Ponderosa Pine Trees Dying from Bark Beetle Attack - R. C. Helker, U. S. Forest Service

The report discusses the ground and aerial studies being undertaken at a bark beetle outbreak near Lead, South Dakota. Optical-mechanical scanning imagery was obtained in 2.0-2.6, 4.5-5.5, and 8.0-14μ wavelengths. Photographic methods were of use in identifying areas of year old infestation, but were useless for previsual detection. No thermal imagery distinguished healthy from infested trees although foliage temperatures measured by radiometers and thermocouples in needles showed 6 to 8°C differences. Microdensitometer traces across thermal scan lines obscured density data. Traces along scan lines permitted analysis of the resolution panels employed, located tree crown groups, and located forest openings; however, healthy and stressed trees were not distinguishable. Scanners with larger collecting optics and better resolution will be required for previsual detection of bark beetle stress.

An Application of Infrared Remote Sensing to Ecological Studies - R. W. Stingelin, HRB-Singer, Inc.

Studies at Bear Meadows Bog, Pennsylvania, were undertaken to determine what advantage could be provided by IR imaging over conventional photography. The studies concluded that nighttime imaging was superior to daytime imaging throughout all seasons. The best nighttime imaging is obtained just before twilight ends. The nighttime imaging degrades slightly toward sunrise. Vegetation studies are best made during evenings with temperatures above freezing. Springs are best detected under subfreezing air temperatures. The masking effect of vegetation is largely eliminated under cold air temperatures. The advantage of IR imagery over conventional photography is that the IR techniques records the response of

vegetation to changing ambient temperatures and seasonal changes in the emittance of the vegetation.

Cirrus Cloud Influence on 6.4-6.9μ Observations, E. S. Merritt et al., Allied Research Associates

The paper reports on the analysis of the Nimbus II surface looking H_2O observations. The analyses indicate that equivalent blackbody temperatures less than 235°K are associated with multi-layered cloud areas, while temperatures of 240°K and higher are found over clear areas; or where cloud tops are below 3km. Tenuous cirrus clouds are not adequately approximated as black-bodies. These clouds are observed by the 6.4-6.9μ channel, but not in concurrent television or radiometric pictures. Studies indicate these clouds have a differential attenuation effect on 6.4-6.9μ and 10.0-11.0μ radiation. Future programs to evaluate this phenomena are suggested.

NEW APPLICATIONS OF MICROWAVE TECHNOLOGY

Radar Scatterometer Data Analysis Techniques, R. K. Moore, et al., CRES, University of Kansas

Moore describes data analysis techniques for categorizing scattering coefficient data for purposes of identifying various terrain surfaces. The complexities of measuring differences using the normal curves of scattering coefficient versus the angles of incidence may be largely eliminated by reducing the dimensionality of the data to three and by the introduction of color. The terrain data is correlated with color chips which are derived by combining three primary colors whose intensity varies with the cross section variation at 5°, 30°, and 60° angles of incidence. The colors permit rapid comparisons of areas as to terrain type. Another method is the construction of scatter plots of slope intercept patterns by plotting the slope versus the viewing angle.

Phased Arrays for Spaceborne Microwave Sensors, M. E. Louapre, Aerojet General Corp.

Airborne or spaceborne microwave radiometer systems produce brightness temperature maps by using the forward motion of the vehicle and a lateral scanning mechanism to provide two dimensioned coverage, or by generating a multiplicity of beams in the same plane.

Both electronically-steered and fixed multiple-beam phased arrays are under development. The potentials of both antenna systems are discussed in terms of such electrical parameters as beamwidth, beam efficiency, beam position, and scan speed.

The Use of Radar in the Discrimination and Identification of Agricultural Land Use, P. E. Schwarz, F. Caspall, CRES, University of Kansas

Statistical analysis of radar data for agricultural information has indicated the following parameters to be significant:

1. The type of crop is the most important variable influencing return.

2. The major influences of return are crop height, percentage of ground covered by vegetation, and row direction.

3. Crop moisture shows a weak relationship to return, and soil moisture shows a slight influence. Other factors, such as microroughness, override the contribution of soil moisture.

4. Some crops depolarize an incident polarized beam to a different degree than others, apparently due to the crop geometries.

OTHER STUDIES

Effect of Pubescence on Reflectance of Light

Study of reflection of light on the velvet plant was undertaken to compare results with tenets present in literature on the effects of pubescence (leaf hairiness). Results of the study showed:

1. Hairiness increased total and diffuse reflectance in the 750 to 1000 mu region, but decreased total and diffuse reflectance between 1000 to 2500 mu.

2. Hairs probably increase reflectance in the 750 to 1000 mu region by scattering incident light or by increasing the amount of transparent surface.

B. E. Sabels

W. L. Smith

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